Influence of NaCl Salinity on the Photosynthetic Pigments of *Crotalaria L.* Species

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Abstract

This paper discusses the effect of NaCl salinity on the photosynthetic pigments in *Crotalaria L.* species. It is seen that the chlorophyll content is decreased in *Crotolariajuncea*, *Crotolariajuncea*var. K-12 yellow and *C. retusa,* whereas there is an increase in the chlorophyll content in *Crotolariaverrucosa* under the saline conditions. In *C. retusa* Chlorophyll 'a' and Chlorophyll 'b' is reduced more prominently at higher salinity levels and in *C. juncea* at lower salinity levels. In *C. juncea*var. K-12 yellow there is decrease in Chlorophyll 'a' and Chlorophyll 'b' whereas in *C. verrucosa* there is an increase in the amount of both Chlorophyll 'a' and Chlorophyll 'b' under saline conditions. The carotenoid content is lowered in leaves of *C. juncea* and in *C. juncea* var. K-12 yellow. In *C. retusa* there is increase in carotenoid content at lower doses. In *C. verrucosa* there is an enhancement in carotenoid content up to 100 mMNaCl. These findings indicate that there is a distinct interspecific variation among various *Crotalaria* species with respect to the retention of chlorophyll under saline conditions.

KEYWORDS:*Crotolaria, Chlorophyll, Carotene, NaCl, Salinity*

Introduction

Soil salinity is an important aspect that needs to be addressed in modern agriculture. Around 20% of the world's cultivated land is affected by soil salinity. Also, almost half of the irrigated land suffers from low agricultural productivity due to soil salinity (Jamil et al., 2011).Globally, agricultural productivity is subdued by both abiotic and biotic stress; more by abiotic stress **(**Araujo et al., 2015)**.** When the electrical conductivity of the soil is 4 dSm^{-1}, it is considered as saline.

NaCl induces a wide range of salt stress **(**Ashraf, 2014)**.**The soil salinity stress on the plants leads to several changes in many metabolic and physiological processes. The severity and duration of the salt salinity stress inhibits the crop production **(**Rozema and Flowers, 2008)**.**

There have been several studies on the inhibitory effect of salinity on photosynthesis, and these studies show that there is a reduction in the photosynthetic pigments in treated plants (Taffouoet al. 2010).There are increasing indications that salt affects the chlorophylls, carotenoids, and the photosynthetic enzymes (Youssef, 2008).

The photosynthesis process helps the plantsto prepare their own food for their growth. It is now known that the chlorophyll content is dependent on saline environment based on the salt levels (Romero-Aranda, 2001).

In this research study we discuss the effect of NaCl salinity on the photosynthetic pigments in *Crotalaria L.* species, which are important nitrogen fixing plants that are used for improving the soil fertility.

MATERIAL AND METHODS

Seeds of *Crotalaria L.* Species were obtained through the courtesy of Sunnhemp Research Station, Pratapgarh, U. P., India. A sand culture technique was employed. A total of 30 seeds were sown in polyethylene culture containers (42 cm x 31 cm) with 2 holes at the bottom, one on each side containing acid free silica sand of about 10 meshes. Hoagland nutrient solution (2 litres) was added to these plants after every 6th day throughout the crop duration.

After one month of establishment, the plants were subjected to treatment of sodium chloride. The following levels of NaCl were selected 0 (control), 50, 100, and 150 mM. The salt treatment was given along with the culture medium twice a week alternating with equal amount of water to avoid evaporation and excess salt accumulation.

The amounts of the chlorophylls were measured using the method proposed by Arnon (1949). These were extracted in the chilled acetone (80%) from an appropriate amount (0.5 gm) of the plant material. The extract filtration was carried out using Buchner funnel. The residue was washed repeatedly with 80% acetone. The final filtrate volume was made to 100 ml with 80% acetone and the absorbance was read at 645 and 663 nm.

The chlorophylls (mg 100 g^{-1} fresh tissue) were calculated using the following equation:

$$\text{Chlorophyll 'a'} = 12.7*A_{@\,663} - 2.69*A_{@\,645} = X$$

$$\text{Chlorophyll 'b'} = 22.9*A_{@\,645} - 4.68*A_{@\,663} = Y$$

$$\text{Chlorophyll } {}^{a}\!/_{b} = \frac{X/Y * \text{Vol. of Extract} * 100}{1000 * \text{Wt. of Plant Material (g)}}$$

The amount of carotenoids was measured by reading the absorbance of acetone extract at 480 m (Kirk and Allen, 1965), and wascalculated by using the following equation(Liasen-Jensen, 1971).

$$C = D * v * f * \frac{10}{2500}$$

where, C represents the total carotenoids in mgs, D represents the optical density, *v*denotes the total volume in ml., *f*denotes the dilution factor, and 2500 represents the average extinction.

RESULTS (NaCl Salinity *and* Photosynthetic pigments)

Chlorophylls: Influence of NaCI salinity on the chlorophyll contents of the leaves of *Crotalaria* species is depicted in Fig. 1. The figure clearly indicates that due to salt stress there is a reduction in chlorophyll content of *C. juncea*, *C. juncea* var. K-12 yellow and *C. retusa*. On the other hand, in *C. verrucosa* the pigment content shows an increase under saline conditions.

In *C. retusa* chlorophyll ‘a’ and chlorophyll ‘b’ are reduced more prominently at higher salinity levels, Similarly, decrease in Chlorophyll ‘a’ and Chlorophyll ‘b’ are also observed in *C. juncea*, but it is prominent at lower salinity level, that is, at 50 mMNaCl. In *C. juncea* var. K-12 yellow there is a decrease in chlorophyll ‘a’ and chlorophyll ‘b’, whereas in *C.verrucosa*, there is an increase in the amount of both chlorophyll 'a' and chlorophyll 'b' under saline conditions.

Chlorophyll a/b ratio has declined in *C. juncea* only, whereas in the other three species there is a slight increase in chlorophyll a/b ratio due to salt stress; except in *C. verrucosa* at 100 mM salinity level.

Among various organic compounds present in the plant cells, chlorophylls are of prime importance because of their involvement in harvesting the solar energy. Higher plants are characterised by the presence of chlorophyll 'a'and chlorophyll 'b', which are part and parcel of the photosynthetic apparatus.

Chlorophylls play a major role in light reactions of photosynthesis. Hence, the chlorophyll content and the state of these pigments influence the photosynthetic efficiency of the plant.

Carotenoids:

The consequence of NaCl salinity on the carotenoid content in the leaves of *Crotalaria* species has been depicted in Fig. 1. It can be seen from the figure that the carotenoid content is lowered in leaves of *C. juncea* and in *C. juncea* var. K-12 yellow. In *C. retusa* there is increase in carotenoid content at lower doses whereas it is decreased at higher concentrations of NaCI. In case of *C. verrucosa* there is enhancement in carotenoid content upto 100 mM NaC1 and at 150 mM it is decreased.

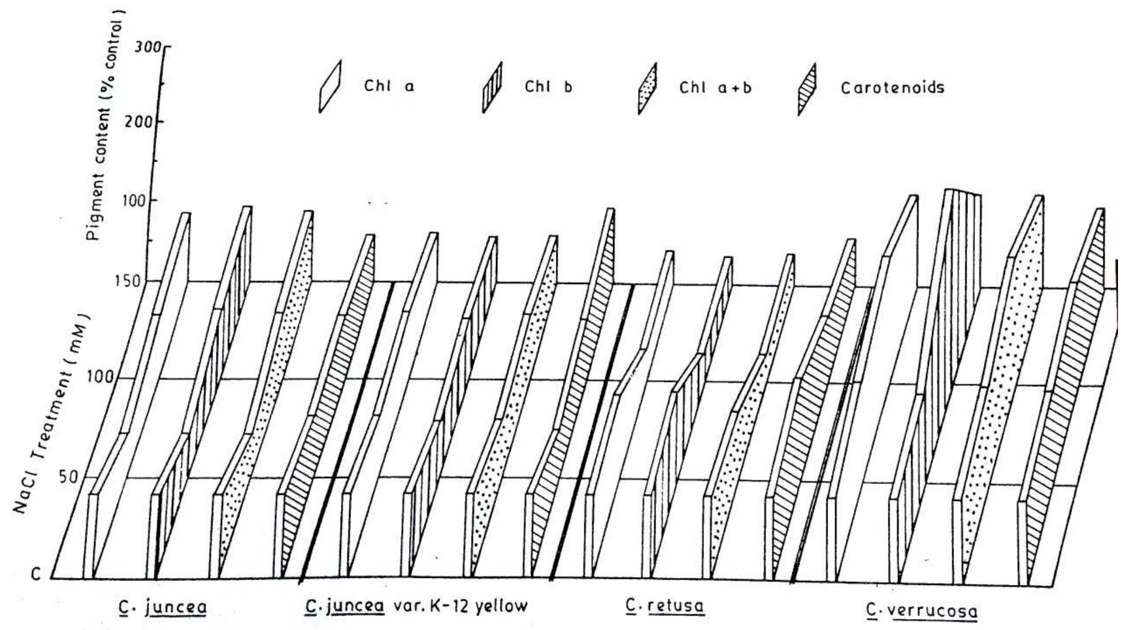

Fig. 1.Effect of NaCl Salinity on Photosynthetic pigment content in the leaves of *Crotalaria* species.

Carotenoids play a secondary role in photosynthetic light reactions. The carotenoids are important part of chloroplast. They play an important role in oxygen transport.Carotenoids certainly function as antenna pigments accepting radiant energy and transmitting it with some losses to chlorophyll 'a' molecules. These metabolic functions of carotenoids have been supported by recent findings of the presence of carotenoids in all native chlorophyll complexes in thylakoids and by their abundance in the chlorophyll envelope. There are few early reports available which describe the effect of NaC1 salinity on carotenoid content of a plant.

Discussion

Decrease in chlorophyll 'a' and chlorophyll 'b' as well as carotenoids has been observed by Amira and Abdul (2011), in *Viciafaba.*According to MuhammadAtif et al. (2013),the decrease in chlorophyll 'a' and chlorophyll 'b' is due to osmotic adjustment in plants, which may be due higher concentration of inorganic ions or organic solutes with low molecule weights.

Amuthavalli and Sivasankarmoorthy (2012) have observed reduction in chlorophyll as well as carotenoids content in *Cajanuscajan.* They are ofthe opinion that the increased degradation and subdued synthesis of that pigment may be the cause of decrease in chlorophyll content.Further, they have inferred that chlorophyll 'a' was less sensitive as compared to chlorophyll 'b'.

K. Khosravinejad et al. (2009) have observed decrease in chlorophyll 'a' and chlorophyll 'b' and carotenoids in two barley varieties. Lopez et al. (2008a) have also observed decrease in chlorophyll and carotene content in the legumes *Lotus japonicas* and *Medicagotruncatula*. Ambede et al. (2012) have observed that salinity caused reduction in chlorophyll 'a' and chlorophyll 'b' and total chlorophyll in both landraces of bambara groundnut.

There are adverse effects of salt on membrane stability, which cause decreasein chlorophyll content.

Conclusion

In this research work the effect of NaCl salinity on the photosynthetic pigments in*Crotalaria L.* species has been studied. It has been observed thata decrease in carotene content may not cause the same degree or damage to photosynthetic process as the one caused by the decrease in chlorophyll pigments because these pigments play rather a secondary role in light reaction of photosynthesis. Nevertheless a decline in carotenes may prove harmful for the chlorophyll molecules in view of the Protective role of these pigments. Our observations indicate that such situation may prevail in leaves of *C. juncea* and *C. juncea* var. K-12 yellow. On the other hand the carotenoids in *C. verrucosa* appear quite stable under saline conditions. Our research findings indicate that there is a distinct interspecific variation among various *Crotalaria* species with respect to the retention of chlorophyll under saline conditions.

References

Ambede J. G, Netondo G. W, Mwai G. N, Musyimi D. M,**2012**.NaCl salinity affects germination, growth, physiology, and biochemistry of bambara groundnut, Braz. J. Plant Physiol. 24(3),

Amira M.S. and Abdul Qados,**2011**. Effect of salt stress on plant growth and metabolism of bean plant *Viciafaba (L.)*, Journal of the Saudi Society of Agricultural Sciences, 10(1), **7-15,**

Amuthavalli P, Sivasankaramoorthy S, **2012.** Effect of salt stress on the growth and photosynthetic pigments of pigeon pea (*Cajanuscajan*), Journal of Applied Pharmaceutical Science, 2(11): **131-133**.

Araujo S. S, Beebe S, Crespi M, Delbreli B, Gonzaliz E. M, Gruber V, **2015.** Abiotic stress responses in legumes: Strategies used to cope with environmental challenges, *Crit. Rev. Plant Sci.*, 34, **237–280**.

Arnon D. I, **1949.**Copper enzymes in isolated chloroplasts: Polyphenol oxidase in *Beta vulgaris*, Plant Physiology, 24, **1-15.**

Ashraf M,**2014.**Some important physiological selection criteria for salt tolerance in plants, *Flora*, 199, **361–376**.

Jamil A, Riaz S, Ashraf M,Foolad M.R. **2011**. Gene expression profiling of plants under salt stress. Crit. Rev. Plant Sci., 30(5), **435–458.**

Khosravinejad F, Heydari R, Farboodnia T,**2009.**Effect of salinity on organic solutes contents in barley, Pak. J. Biol. Sci., 12 (2), **158–162**.

Kirk, J. T. O, and Allen R. L, **1965**.Dependence of chloroplast pigments synthesis on protein synthetic effects on actilione, Biochem. Biophysics Res. J. Canada, 27, **523-530.**

Liasen-Jensen S, and Jensen A, **1971**.Quantitative determination of carotenoids in photosynthetic tissues, Methods in Enzymology (Ed. San Pietro, A.) Academic Press, Inc., Publishers, NY, **586-602.**

Lopez M, Herrera-Cervera J. A, Iribarne C, Tejera N. A, Lluch C, **2008a.**Growth and nitrogen fixation in Lotus japonicas and Medicagotruncatula under NaCl stress: Nodule Carbon metabolism, J Plant Physiol, 6, **641-650**.

Muhammad A, Ammara S, Nabeela R, Amina S and Sonia A, NaCl Salinity a Deleterious Factor for Morphology and Photosynthetic Pigments Attributes of Maize (*Zea mays L.*), World Journal of Agricultural Sciences 9 (4), **305-308, 2013**.

Romero-Aranda R, Soria T, and Cuartero S,**2001.**Tomato plant-water uptake and plant-water relationships under saline growth conditions, Plant Sci., 160, **265-272**.

Rozema J. and Flowers T,**2008.**Crops for a salinized world. Science,322, **1478–1480**.

Taffouo V. D, Wamba O. F, Yombi E, Nono G. V, Akoe A, **2010.**Growth, yield, water status and ionic distribution response of three bambara groundnut (*Vigna subterranean (L.)verdc.*) landraces grown under saline conditions, Int. J. Bot. 6 (1), **53–58**.

Youssef T, Awad M, **2008.** Mechanisms of enhancing photosynthetic gas exchange in date palm seedlings (*Phoenix dactyliferaL.*) under salinity stress by a 5-aminolevulinic acid-based fertilizer, Journal of Plant Growth Regulation, 27, **1–9**.